Effect of Increased Traffic on Controller Workload

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Introduction

- Controller workload has been a focal topic in air traffic management research over the years
  - e.g. Stein, 1985; Mogford, Guttman, Morrow, & Kopardekar 1995; Manning, C. A., Mills, S. H., Fox, C. M., Pfleiderer, E., & Mogilka, H., 2001
  - Workload considered a key bottleneck to capacity increase
  - Multiple factors contribute to controller workload
    - e.g. aircraft count, amount of air-ground communication, number of altitude clearance, number of unresolved conflicts, etc.
    - Aircraft count is one of the better predictors of controller workload

Nature of Subjective Workload

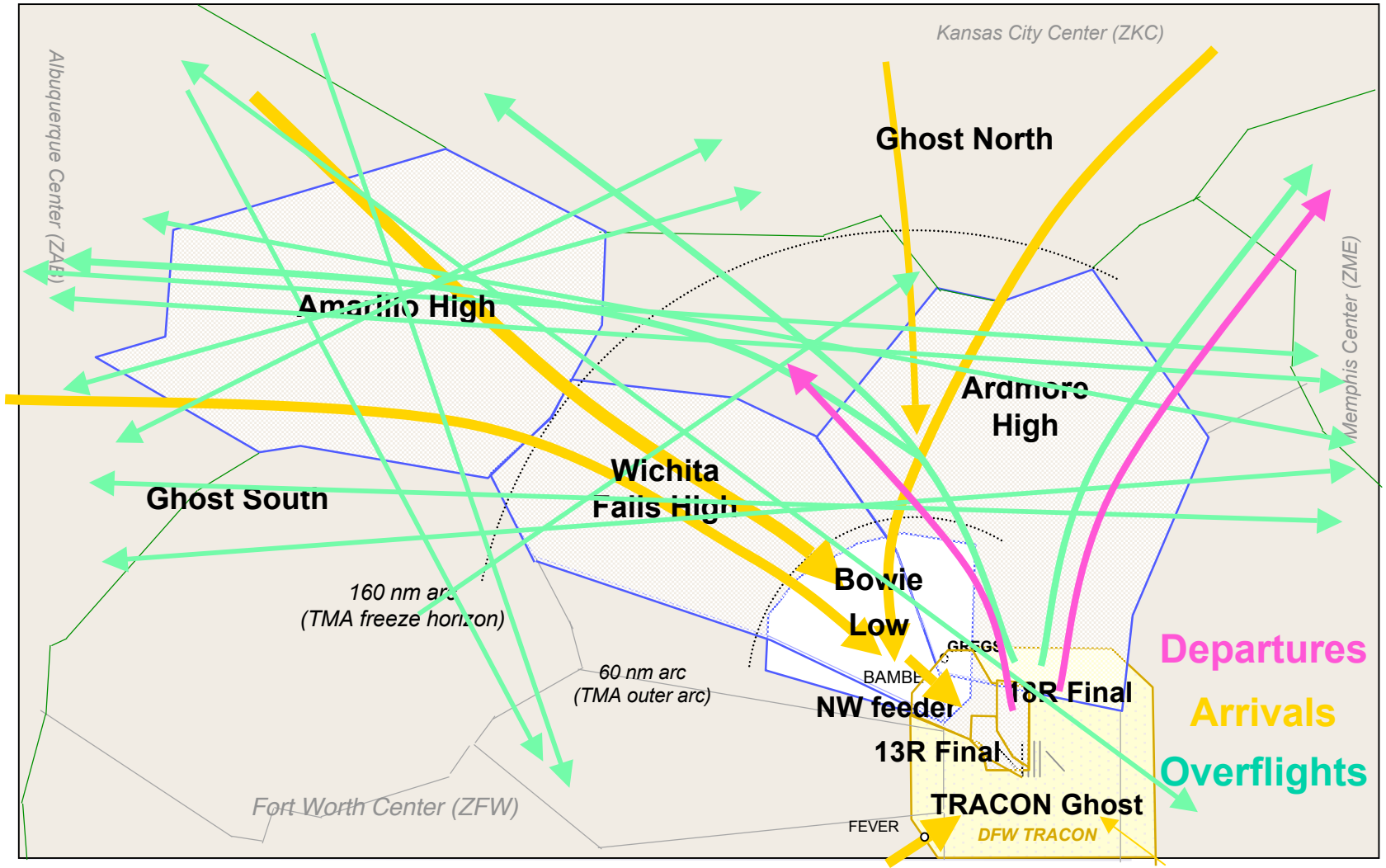
- Past research focused on identifying factors contributing to workload
  - Factor analysis to identify the contributing factors
  - Multivariate regression to fit the data
- This approach doesn't seem to capture the subjective experience of workload increase
  - Controllers report low/moderate workload ratings for busy traffic problems, but…
  - Report high workload ratings with few added tasks and/or off-nominal situations at some "breaking point"
- A controller *perceives* the workload to be low until the traffic and associated task load increase to reach a critical point. From this point, the workload increases much faster with each added task
- Non-linear relationship exists between objective metrics (e.g. traffic count, number of clearances) and subjective workload

Traffic Load Test

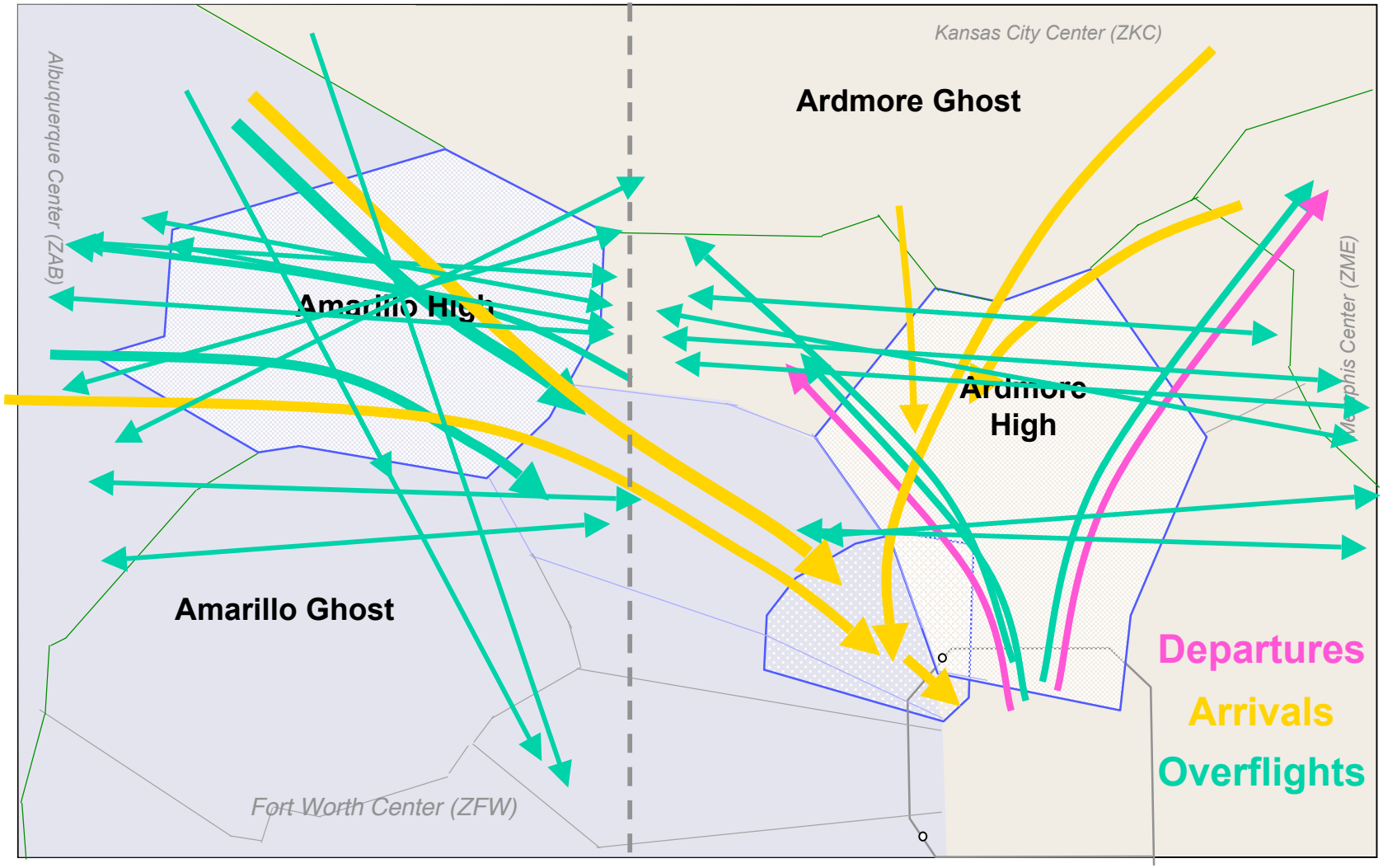
- To examine the non-linear nature of workload, traffic needs to be near maximum threshold

- Traffic Load Test
  - Informal studies as a precursor to testing DAG-TM concepts
  - Manipulated aircraft count to determine critical traffic levels at which traffic becomes unmanageable
  - As hypothesized, the workload increased gradually until a critical traffic level after which the traffic quickly became unmanageable
  - Feedback from the controllers further supported the non-linear nature of subjective workload

Simulated Airspace



Traffic Load Test: Single-Sector Airspace



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Traffic Load Test Goals

- Goal is to determine maximum aircraft count in Amarillo & Ardmore sectors
- Results served as index value for establishing traffic levels for DAG-TM simulation in June
- Expect maximum level within these sectors could vary greatly due to differences in traffic complexity:
  - Amarillo (in our scenarios) has primarily level flight overflights
  - Ardmore has crossing streams of metered arrivals, overflights (E-W and N-S) and DFW departures

Test Procedures

Participants

- 2 FPL controllers
- 2 retired controllers / supervisors

Scenarios

- 30 minute scenarios
- Traffic
  - Ramps up for 15 minutes
  - Sustained at maximum aircraft count for 10 minutes
  - Drops off gradually for the last 5 minutes
- Simulation of single-sector traffic scenarios
  - Two “worlds” run in parallel
  - Supervisor/ghost controllers feed the traffic to FPL controllers

Test Procedures

Procedures

- Training/familiarization with tools, traffic levels, and procedures
- Discuss the working definition of “unmanageable traffic”
- Data collection runs
  - Run initial sector problem at level determined in training
  - After running each scenario, controllers rate load relative to threshold traffic
  - Next scenario will increase or decrease traffic based on joint assessment by controllers and supervisors
  - This process continues until threshold traffic is established

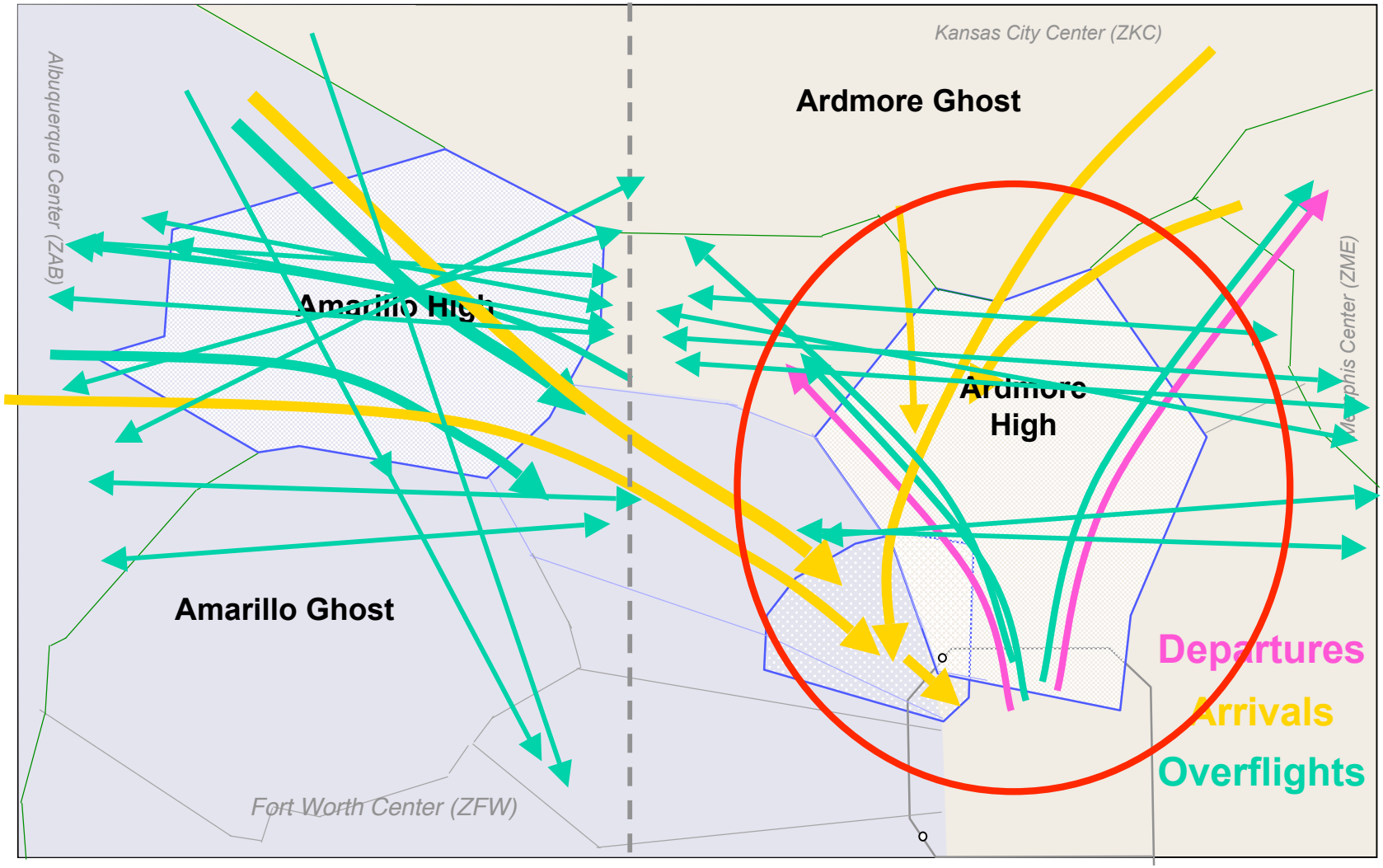
What does unmanageable mean?

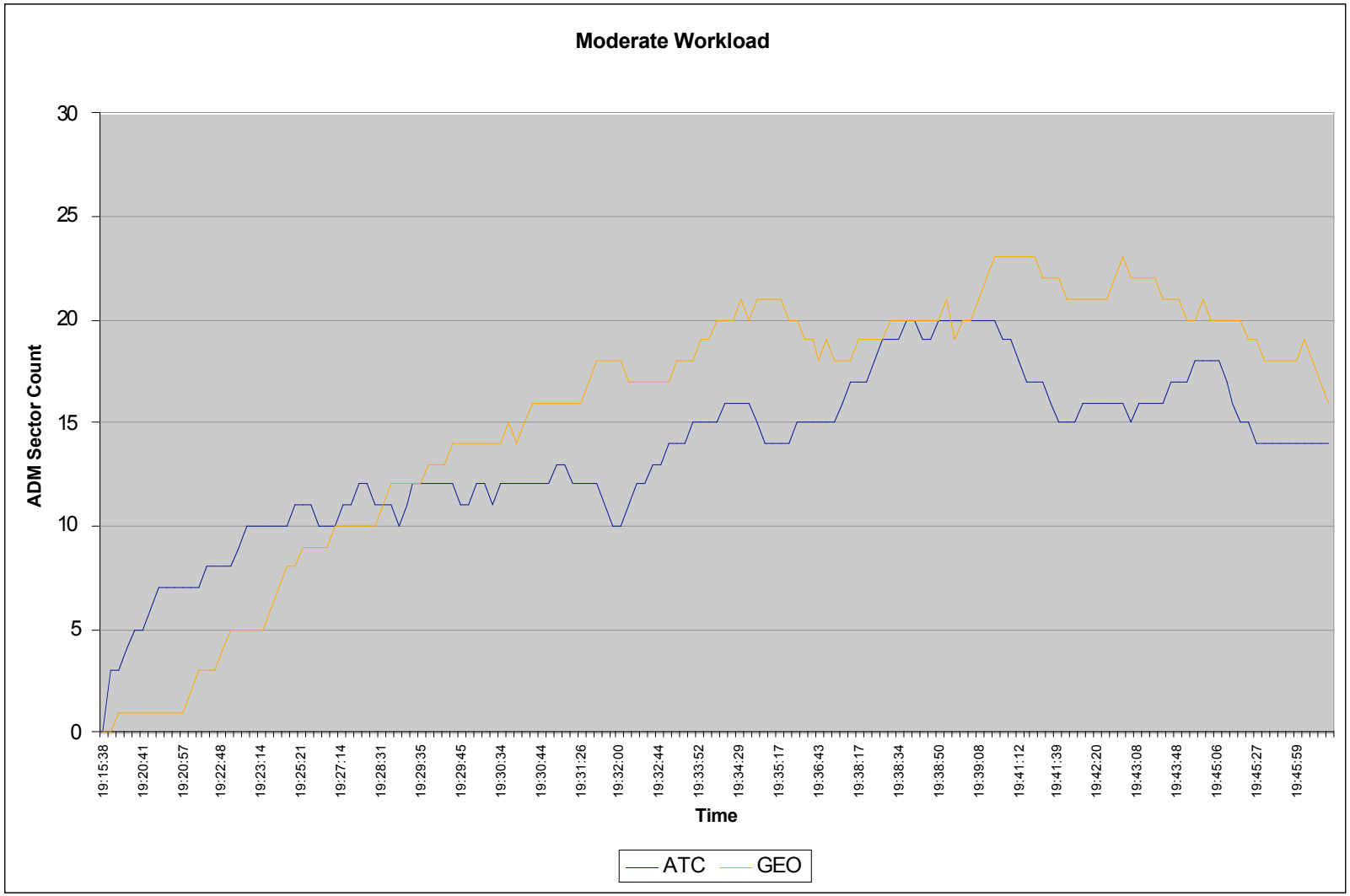
- Loss of situation awareness
- Loss the “flick”
  - Having the flick is having the picture; you have the situation, you know the situation, have a plan, are working proactively, supervisor, other controllers notice, pick up on language, body language, and provide help.
- Compromised safety
- One more problem will put you down the tubes
  - Even something as simple as an altitude request

- Potential Symptoms
  - handoffs are late
  - can’t find checking-in flights easily
  - reactive instead of proactive
  - don’t know where planes are
  - over-reliance on tools
  - situation startles you
  - service goes out the window

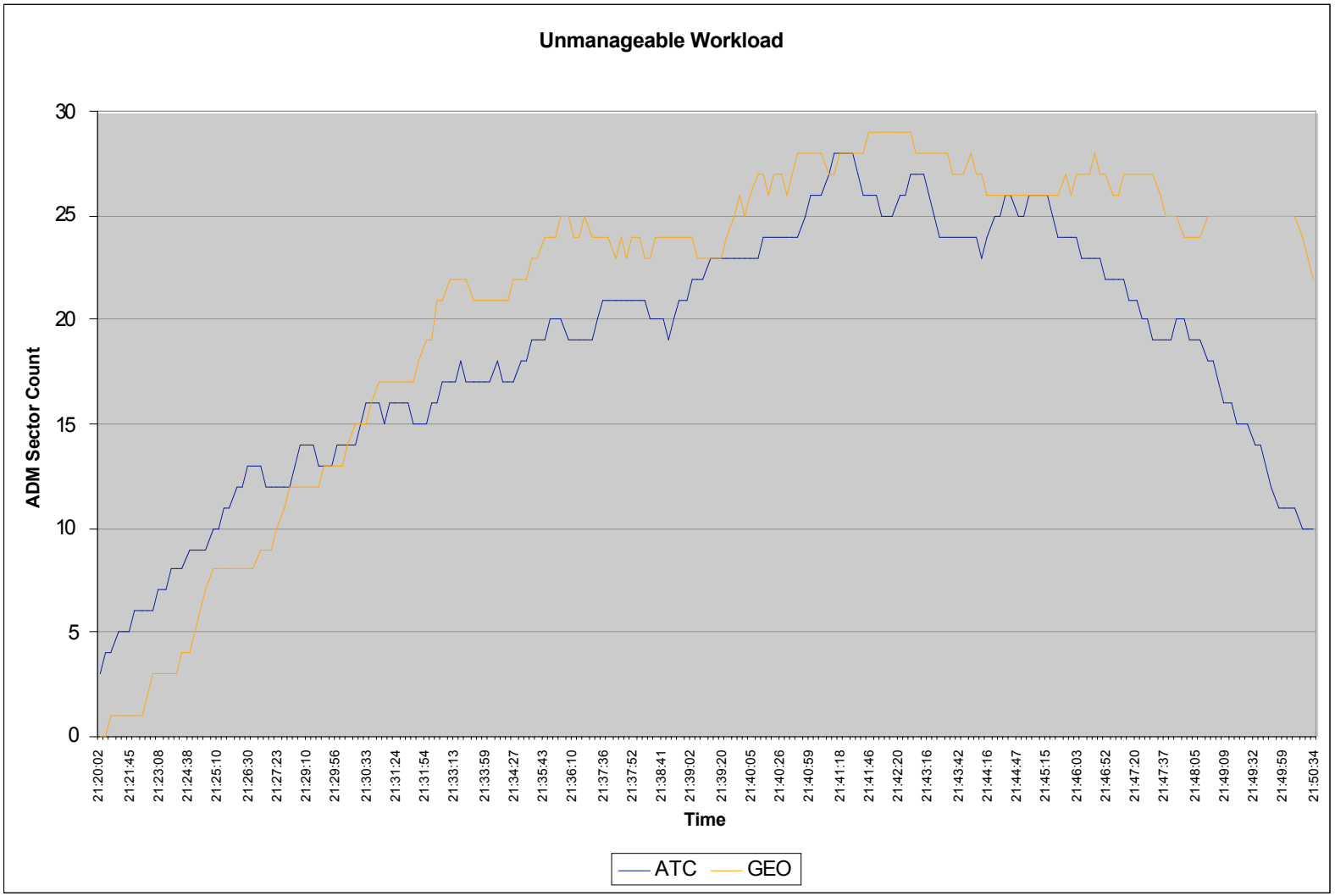
Remarkable agreement among participants on what constitutes unmanageable traffic during data collection

Results: Ardmore Sector Aircraft Counts

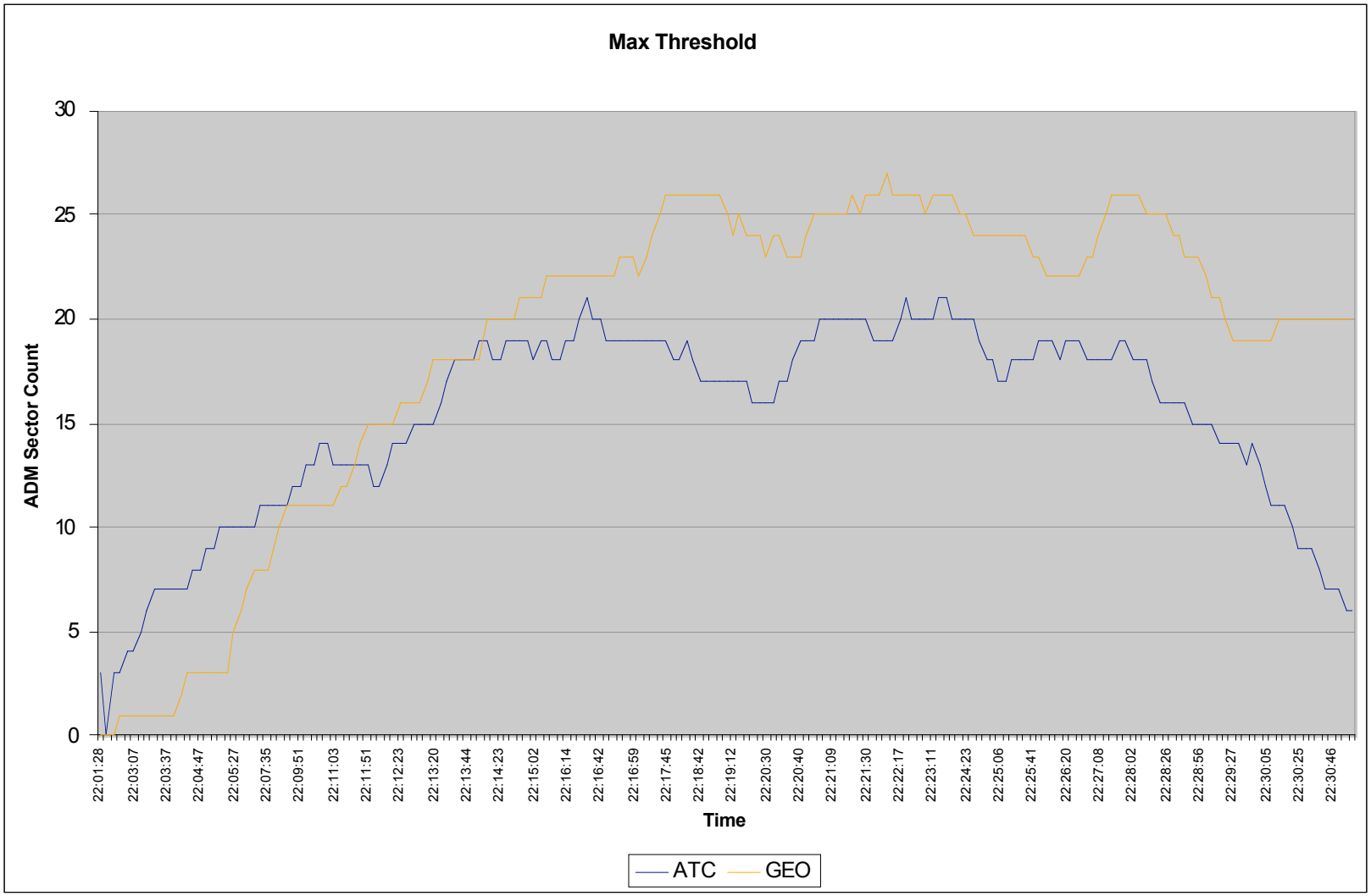



Moderate Workload
ADM Sector Count
30
25
20
15
10
5
0
19:15:38
19:20:41
19:20:57
19:22:48
19:23:14
19:25:21
19:27:14
19:28:31
19:29:35
19:29:45
19:30:34
19:30:44
19:31:26
19:32:00
19:32:44
19:33:52
19:34:29
19:35:17
19:36:43
19:38:17
19:38:34
19:38:50
19:39:08
19:41:12
19:41:39
19:42:20
19:43:08
19:43:48
19:45:06
19:45:27
19:45:59
Time
ATC
GEO

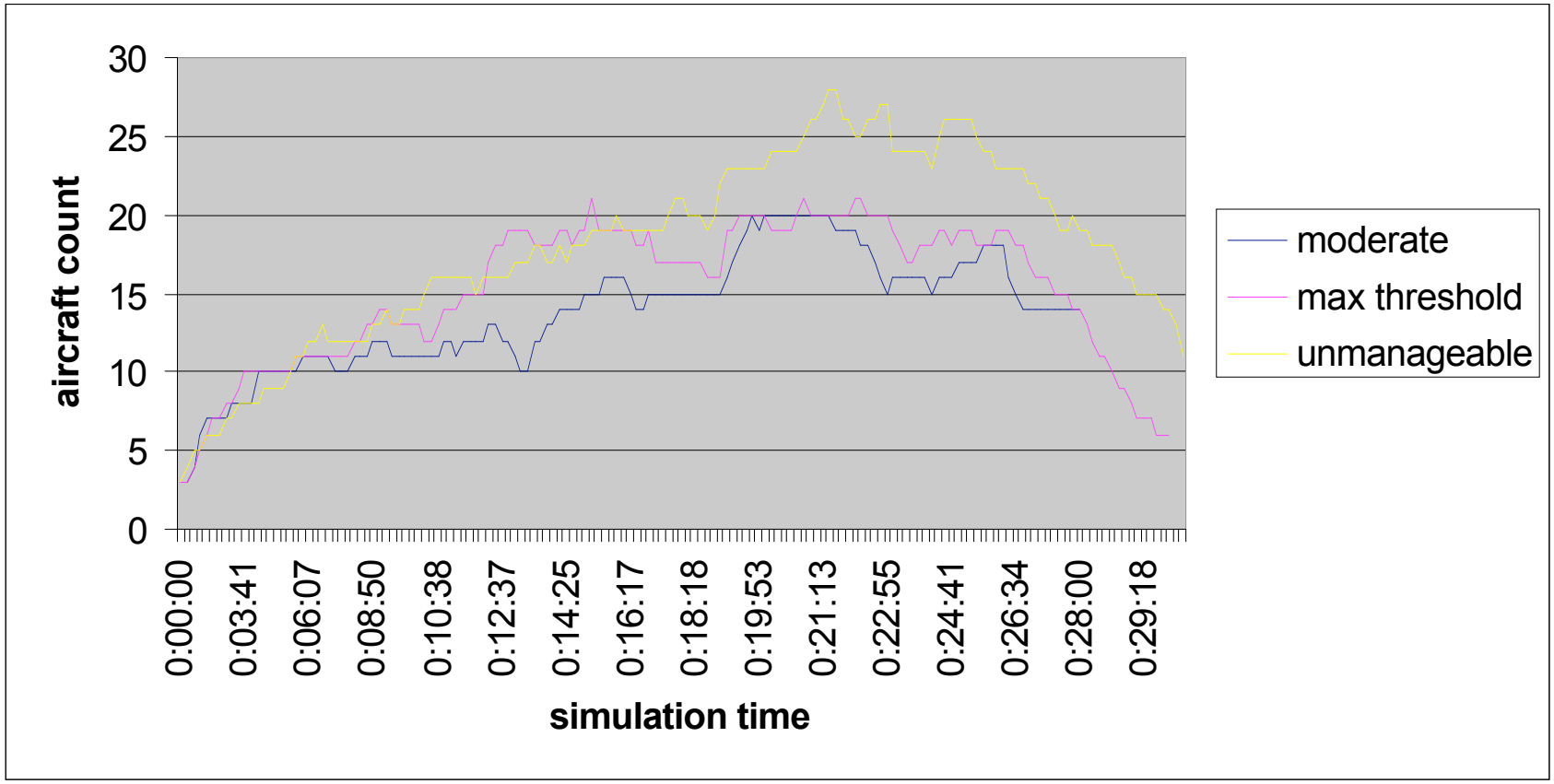
Data Run 2: ATC Feedback – Definitely Unmanageable



Data Run 3: ATC Feedback – Maximum Threshold



Combined Plots: Owned A/C Count

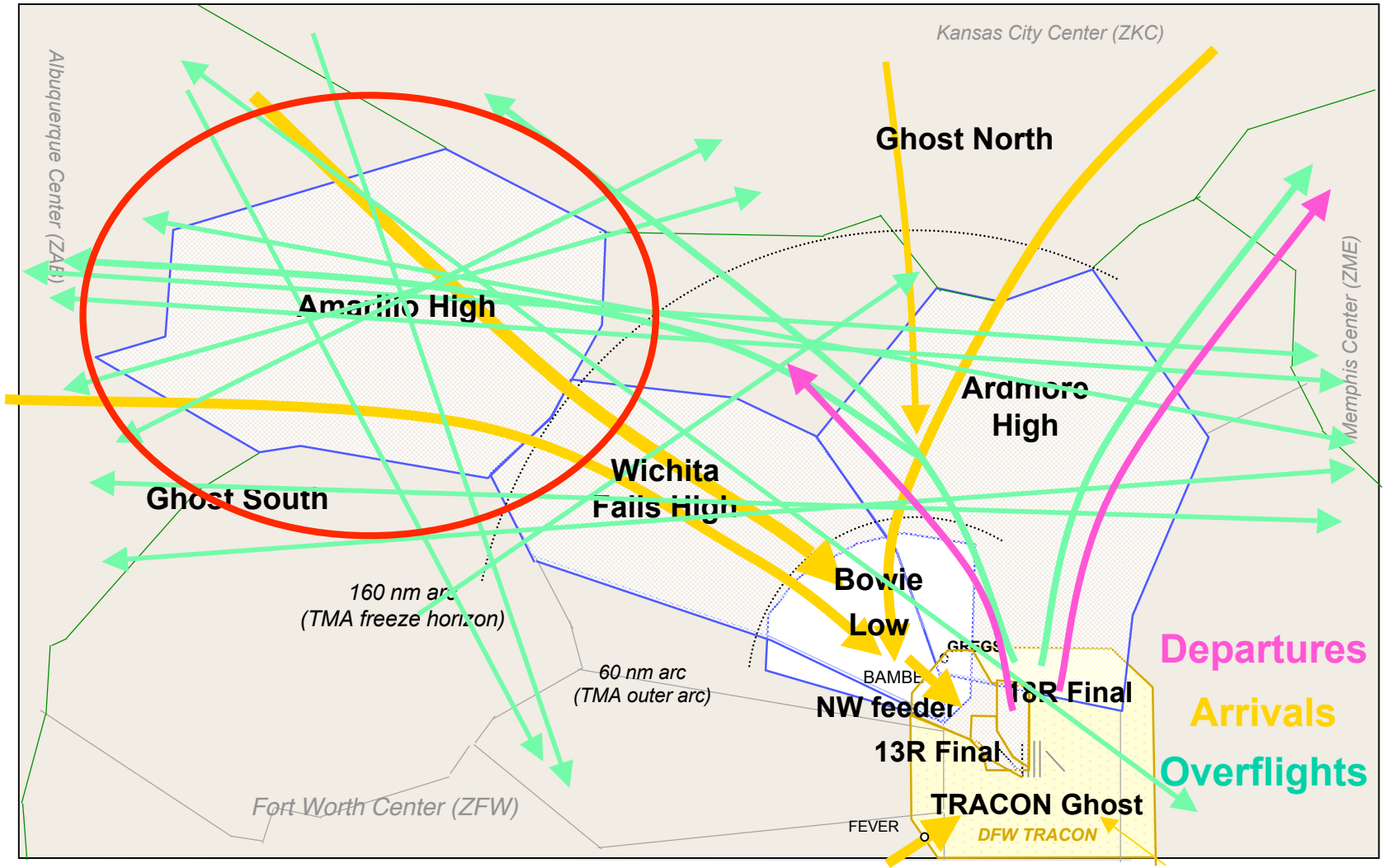


Further Insights from Subsequent CE 5 Study

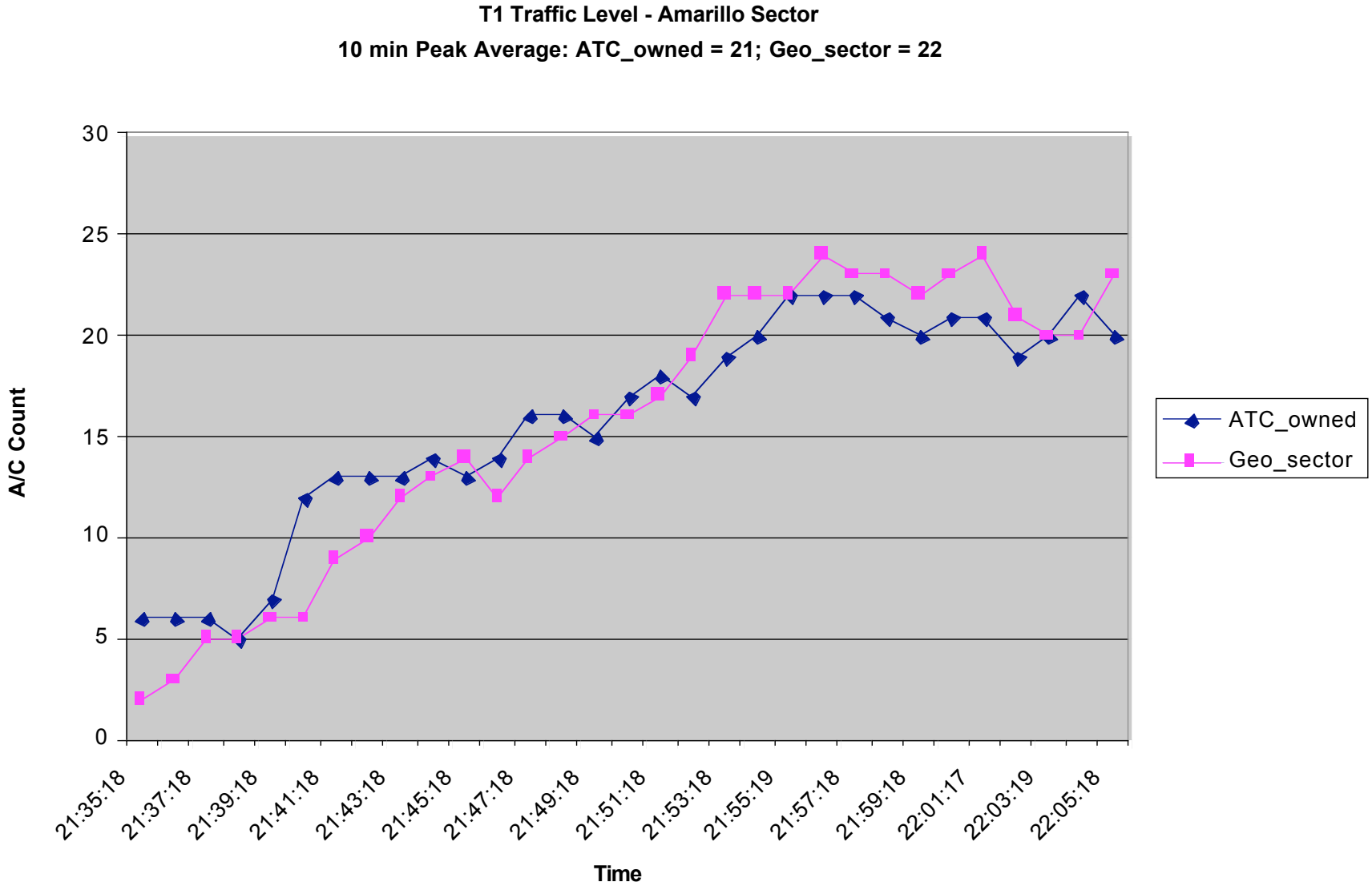
- CE 5 – Free maneuvering concept
  - Mixed airspace of
    - Controller-managed aircraft (current day)
    - Free maneuvering aircraft
      - Minimal controller involvement
      - Separation responsibility to the pilots
  - Results
    - Controller workload correlated mostly with managed portion of the traffic

- To gain further insights into the relationship between workload and traffic level
  - Examine controller workload and managed portion of the traffic – i.e. ignore free maneuvering aircraft in the analyses

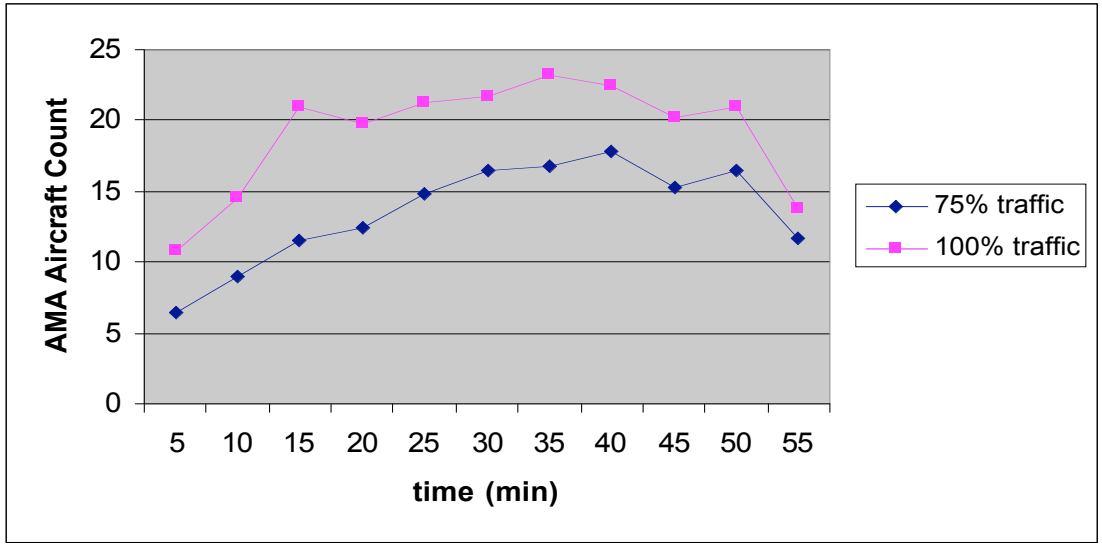
Results: Amarillo Sector Aircraft Count & Workload



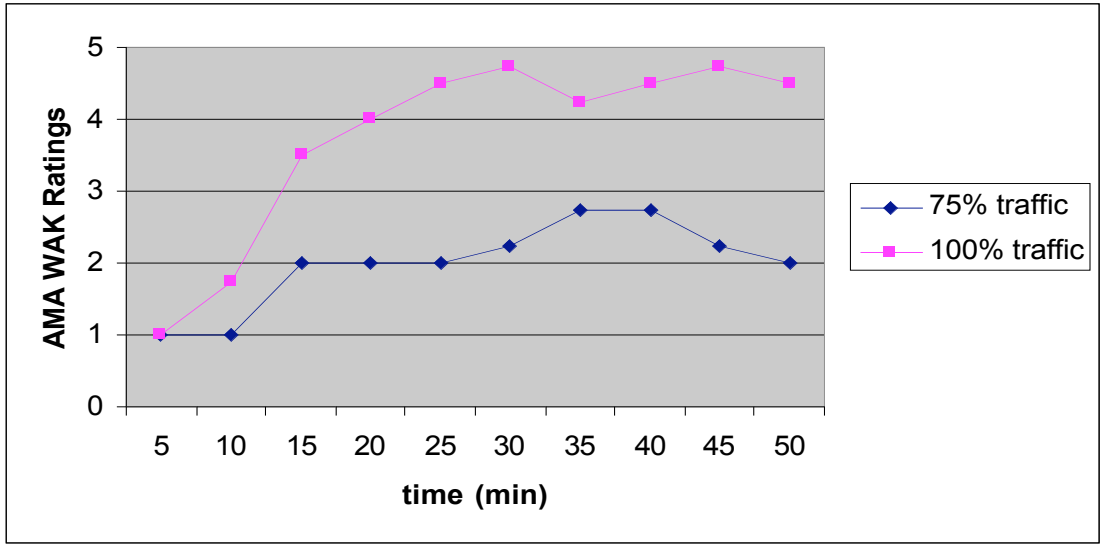
AMA: Threshold Traffic from Load Test



Comparison of Aircraft Count & Workload

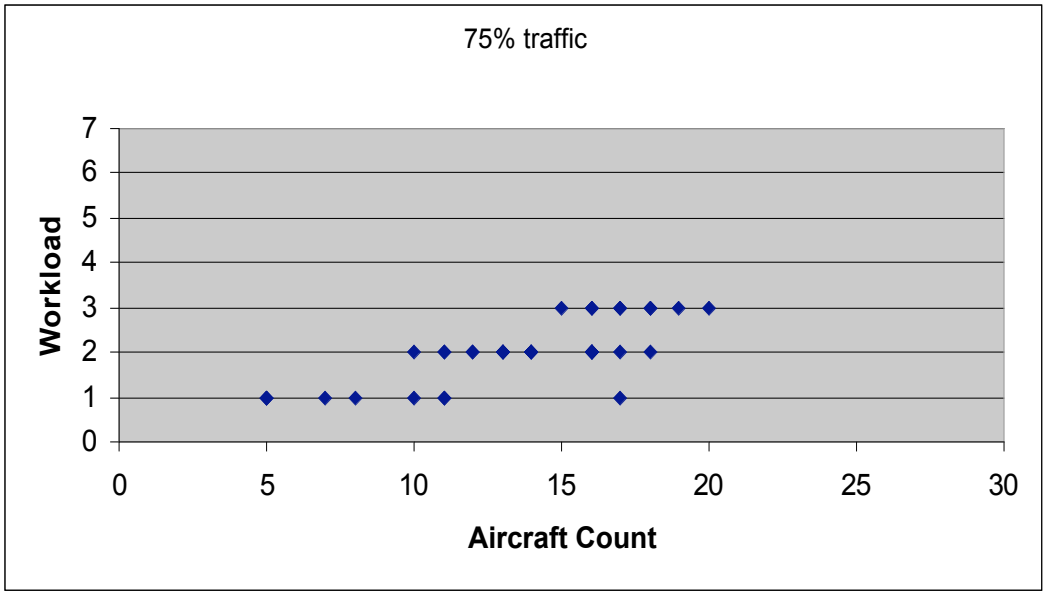


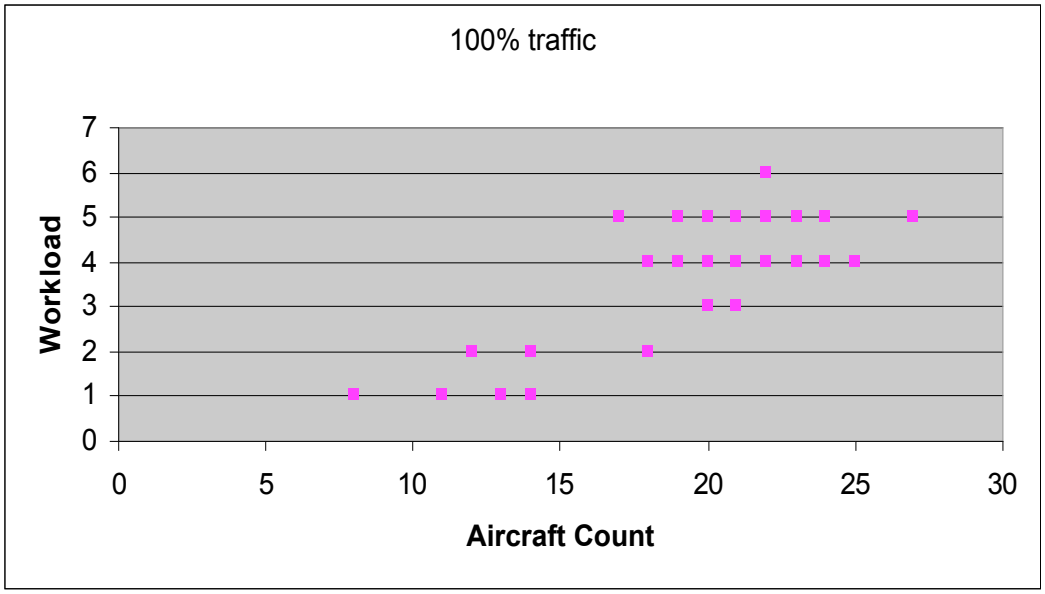
Aircraft Count



ATC Workload

Scatter Plot: Workload vs. A/C Count





Summary

- Controllers / supervisors have good intuitive understanding of “unmanageable” traffic
- Subjective workload is non-linear to increase in aircraft count
  - Likely non-linear relationship with other objective task load metrics (e.g. number of conflicts, handoffs, etc.)
  - Implications
    - Workload cannot be linearly extrapolated from measured workload
    - Perceived workload is not interchangeable with objective task load
- Further analyses needed on workload vs. other task load metrics (e.g. Number and types of clearances, task duration)